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Sensory Evaluation on Flavor, Volume and Texture of Substituting Amaranth Flour for Wheat Flour in Red Velvet Cupcakes

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Introduction

Celiac disease is an autoimmune disease that is becoming more prevalent in the past decade. Celiac disease is a condition in which gluten, a protein found in many grains like wheat, rye and barley, causes damage to the small intestine. Current statistics indicate that 1 in 141 Americans has celiac disease (National Institute of Diabetes and Digestive and Kidney Diseases, 2016). In terms of nutrition therapy, celiac patients simply avoid consuming foods with gluten-containing grains.

In our society today, this eliminates many types of pasta, breads, and other baked goods, which make up the bulk of the Western diet. Some major grocery store chains and restaurants have started offering gluten-free options to their customers over the last few years, but the options they offer are limited.

There has been research into other viable options for celiac patients using other types of grains. A study in 2015 used variants of Andean corn to make spaghetti to determine the acceptability among celiac patients (Gimenez et al., 2015). The study found that many of the celiac subjects were preferable to the Andean corn spaghetti. Another study by Rodrigues Batista, De Morais, Caliari and Junior (2016) had used rice flour mixed with potato pulp to make gluten-free biscuits. Their aim was to show an acceptable product made from the flour and pulp. The study determined that the pulp, which was made from potato waste at a French fry processing plant, could provide a means to eliminate food waste and provide an acceptable product for celiac patients.

Some research has also looked at improving the nutritional quality of gluten-free products by using grains like amaranth or quinoa. Amaranth is a grain that is gluten-free and it has been introduced as an alternative to wheat flour in many flour-based products (Brown, 2015).

Amaranth contains the amino acid lysine, which few grains do. Because of this, amaranth is considered to be a complete protein, and beneficial to celiac patients that want to adopt a vegetarian lifestyle (Whole Grains Council, 2016).

It is becoming a common practice in Third World countries to incorporate legumes, like chickpeas, into amaranth containing products. Besides the complete protein, amaranth contains many vitamins and minerals, like calcium, zinc and iron. A recent study in Uganda revealed that a population that consumed recipes containing amaranth greatly improved their nutritional status in terms of calcium, iron and zinc intake (Tibagonzeka, Wambete, Muyinda, Nakimbugwe, & Muyonga, 2014).

A study in Ethiopia found that a porridge containing amaranth and chickpeas was nutrient rich and could be produced at a low cost, thus helping provide meals to the disadvantaged (Zebdewos, Singh, Brihanu, Whiting, Henry, & Kebebu, 2015). While malnutrition is not as large of a problem in the United States, research has shown the nutrient benefits of adding amaranth to the diet.

Yamsaengsung, Berghofer, and Schoenlechner (2012) researched the sensory effects and acceptability of adding chickpeas to various wheat flours and then compared their nutrient profiles to those of gluten-free flours like amaranth flour. The researchers determined that the chickpeas improved the protein profile and the overall acceptability of the amaranth cookies.

Research Objectives

The purpose of this study to test the flavor, texture, volume and overall acceptability of two red velvet cupcakes, one prepared with all-purpose flour and the other prepared with amaranth flour. The goal of the study is to determine if amaranth flour could be used as an ingredient in other baked goods. This could provide celiac patients with more gluten-free options

for desserts or other treats. The hypothesis is that there will be no difference in volume or texture between the two cupcakes, and the cupcakes prepared with amaranth flour would be accepted.

Methods

Protocol

The procedure in this study to prepare two versions of red velvet cupcakes, using the recipe below (allrecipes.com, 2016). Both samples would undergo objective testing for volume, as well as a single-blind sensory evaluation by a group of panelists.

Red Velvet Cupcakes

Ingredients

Home Measures	Metric Units
¼ cup vegetable shortening	48 g vegetable shortening
¾ cup white sugar	150 g white sugar
1 egg	52 g egg
1 tbsp. cocoa	7 g cocoa
2 tbsp. red food coloring	30 mL red food coloring
½ tsp salt	4 g salt
½ tsp vanilla extract	3 mL vanilla extract
½ cup buttermilk	120 mL buttermilk
1 ¼ cup sifted all-purpose flour	142 g sifted all-purpose flour
¾ tsp baking soda	5 g baking soda
½ tbsp. distilled white vinegar	8 mL distilled white vinegar
1 16 oz tub of premade cream icing	1 454g tub of premade cream cheese icing

Equipment

Conventional Oven	2 liter mixing bowl	100 mL graduated cylinder
100 mL beaker	Digital kitchen scale	10mL graduated cylinder
Kitchen timer	Sifter	Toothpicks
1 liter mixing bowl	50 mL beaker	Kitchen-aid mixer
Rubber spatula	Wax paper	5-cm wax cupcake cups
5-cm cupcake pan		

Instructions

1. **Preheat oven to 180° C. Lightly grease cupcake pan.**

2. **Combine shortening and sugar**

   In a Kitchen-aid mixing bowl, combine 48 g of vegetable shortening and 150 g of granulated white sugar. Using a wire whisk attachment, beat the mixture until light and fluffy.

3. **Beat egg and add to mixture**

   In a 100-mL beaker, beat 52 g of egg well and add to mixture.

4. **Combine cocoa powder and red food coloring; add to mixture**

   In a 100-mL beaker, combine 7 g of cocoa powder and 30 mL of red food coloring and mix into a paste. Add paste to mixture of shortening, sugar and egg.

5. **Combine salt, vanilla extract and buttermilk**

   In a 250-mL beaker, combine 4 g of salt, 3 mL of vanilla extract, and 120 mL of buttermilk.

6. **Add flour and buttermilk mixture to batter**

   Alternate adding the 142 g of sifted all-purpose flour and buttermilk mixture, mixing just until incorporated.

7. **Add baking soda and vinegar**

   Add 5 g of baking soda and 8 mL of distilled white vinegar to the batter mixture, folding gently into mixture. Do not beat or stir the mixture after this step.

8. **Pour batter into paper muffin cups and bake**

   Measure 16 g of batter into 5-cm wax cupcake cup and place into prepared cupcake pan. Repeat as needed. Bake in preheated oven until a toothpick inserted into the cupcake comes out clean, about 12-16 minutes.

9. **Remove from pan and place on wire rack**

   Take cupcakes out of the oven and place them on wire rack to cool, approximately 1 hour.

10. **Add icing to cupcakes**

    Add 4 g of icing to cooled cupcake. Repeat as needed.

Modified Recipe. For the modified recipe, repeat all steps in the original recipe. The only alteration is on Step 6, where 142 g of sifted amaranth flour is substituted for the 142 g of sifted all-purpose flour.

Objective Testing: Seed-Displacement Test.

A seed-displacement test was used for this experiment as it was best to determine the volume of the cupcakes (McWilliams, 2012).

1. Fill a beaker partially with barley seeds and shake to level. Repeat until beaker is full of barley seeds. Use a flat spatula to level the top of the beaker. Measure weight.
2. Remove barley, add cupcake and partially refill beaker with barley seeds, shaking again to level off. Repeat until beaker is full of barley seeds and leveled off.
3. Pour the seeds into a container. Remove the cupcake and measure the displacement.
4. Repeat steps 1-3 twice. Take mean of the results.

Sensory Evaluation

A group of five panelists were simultaneously presented with both samples and scorecards for each sample. The control sample was labeled as “Sample A” and the modified sample was labeled as “Sample B.” An IRB-approved script was read to all panelists and their consent to participate was given to the researcher. The panelists were instructed to judge each sample based

on characteristics relating to texture and flavor. The scorecard was designed with ordinal scales, descriptive testing, one open-ended description question, and concluded with a sample preference question.

Initials: _____

Sample A

Please select the option that best represents each category.

Chewiness	Very Tender								Very Tough
Mouthfeel	Very Sticky or Gummy								Very Grainy
Texture	Smooth, Velvety								Rough, Crunchy
Aftertaste	No Aftertaste								Distinct Aftertaste

Please circle the responses that best represents this sample:

Flavor:

Sweet **Bitter** **Pasty** **Floury** **Sour** **Nutty**

Texture:

Dry **Crunchy** **Creamy** **Lumpy** **Burnt**
Moist

Please describe your overall impression of the sample:

Initials: _____

Sample B

Please select the option that best represents each category.

Chewiness	Very Tender								Very Tough
Mouthfeel	Very Sticky or Gummy								Very Grainy
Texture	Smooth, Velvety								Rough, Crunchy
Aftertaste	No Aftertaste								Distinct Aftertaste

Please circle the responses that best represents this sample:

Flavor:

Sweet **Bitter** **Pasty** **Floury** **Sour** **Nutty**

Texture:

Dry **Crunchy** **Creamy** **Lumpy** **Burnt**
Moist

Please describe your overall impression of the sample:

Please indicate which sample you would prefer: **SAMPLE A** **SAMPLE B**

Nutrient Analysis

Original Recipe	
Serving: 1 cupcake	
Servings: 12	
Calories	308 kcal
Calories from Fat	103 kcal
Total Fat	11 g
- Saturated Fat	2.5 g
- *Trans* Fat	0 g
Cholesterol	17 mg
Sodium	264 mg
Carbohydrates	49 g
- Dietary Fiber	Less than 1 g
- Sugar	37 g
Protein	2 g
Vitamin A	1 %
Vitamin C	0 %
Calcium	1 %
Iron	10 %

Modified Recipe	
Serving: 1 cupcake	
Servings: 12	
Calories	303 kcal
Calories from Fat	109 kcal
Total Fat	12 g
- Saturated Fat	3 g
- *Trans* Fat	0 g
Cholesterol	17 mg
Sodium	267 mg
Carbohydrates	47 g
- Dietary Fiber	1 g
- Sugar	37 g
Protein	2 g
Vitamin A	1 %
Vitamin C	0 %
Calcium	3 %
Iron	14 %

The differences between the two recipes are minimal in terms of the nutrient analysis. Both recipes provide approximately the same number of calorie and carbohydrates, and both are low in cholesterol and saturated fat, which could help lower the risks of hypertension and cardiovascular disease. One notable difference is that the modified recipe does offer more calcium, which is beneficial for bone health. There is also a slight increase in fiber content with the modified recipe, which helps with satiety. Another increase is the iron content in the modified recipe, providing nearly fifty percent more than the original recipe.

Results

From the results of the seed-displacement test, Sample B, or the sample prepared with amaranth flour, had slightly more volume than the control sample, Sample A. The results show that there is not a discernable difference in volume between baking with amaranth flour and all-purpose flour.

It is interesting to point out this similarity, as gluten is a contributing factor to the volume of baked goods (Brown, 2015).

The results of this test are listed in the table below.

Seed Displacement Test				
	Measurement 1	Measurement 2	Measurement 3	Mean
Sample A [Control]	454 mL	456 mL	452 mL	454 mL
Sample B [made with amaranth flour]	460 mL	458 mL	460 mL	459.3 mL

Regarding the sensory data gathered from the panelists, Sample A, which was made with all-purpose flour, was found to be more tender and sweet than Sample B. Sample B, made with amaranth flour, was found to be more bitter tasting and having a distinct aftertaste. Some described the taste of Sample B as "potting soil." Sample B was also determined to have a nutty flavor, while one noted it was sour in taste too.

In terms of texture, many of the panelists stated that the Sample B cupcake was moist, but some claimed it was also dense. The panelists agreed that Sample A had a moist texture as well. The panelists described both samples as neither grainy or gummy. None of the panelists described either sample as crunchy or burnt.

In regards of the overall preference, 60% of the panelists preferred the control over the modified cupcake. The sensory data collected from the panelists is listed in the tables below.

Chewiness:

Sample	Panelists [Labeled 1-5]					**Mean**	**Median**	**Mode**
A	1	1	4	1	1	**1.6**	**1**	**1**
B	1	1	4	5	2	**2.6**	**2**	**1**

Mouthfeel:

Sample	Panelists [Labeled 1-5]					Mean	Median	Mode
A	4	2	6	4	4	**4**	**4**	**4**
B	1	5	2	2	4	**2.8**	**2**	**2**

Texture:

Sample	Panelists [Labeled 1-5]					Mean	Median	Mode
A	2	2	4	2	5	**3**	**2**	**2**
B	4	2	4	3	2	**3**	**3**	**2,4**

Aftertaste:

Sample	Panelists [Labeled 1-5]					Mean	Median	Mode
A	6	1	1	1	6	**3**	**1**	**1**
B	7	6	7	5	1	**5.2**	**6**	**7**

Descriptive Test:

Sample A	**Sweet**	**Bitter**	**Pasty**	**Floury**	**Sour**	**Nutty**
Flavor	3			2		1
	Dry	**Crunchy**	**Creamy**	**Lumpy**	**Burnt**	**Moist**
Texture	1		1			3

Sample B	**Sweet**	**Bitter**	**Pasty**	**Floury**	**Sour**	**Nutty**
Flavor	1	2	1		1	2
	Dry	**Crunchy**	**Creamy**	**Lumpy**	**Burnt**	**Moist**
Texture			1			4

Themes:

	Sample A	**Sample B**
Pleasant Flavor [1]	4	1
Sweet [2]		
Bitter [3]		1
Dirt Flavor [4]		2
Aftertaste [5]		2
Moist [6]	1	1

Overall Preference:

Sample A [made with all-purpose flour]	60%
Sample B [made with amaranth flour]	40%

Conclusion

After reviewing the objective data collected, it was determined that there was no difference in volume between the two samples. The amaranth flour could create a cupcake that was similar in volume to the all-purpose flour cupcake, which was interesting because it lacked the gluten.

The sensory data revealed that the textures between the two cupcakes were also very similar, as both were found to be moist and mostly tender. It was determined that while the amaranth flour cupcake could be similar in volume and texture to the all-purpose flour cupcake, but it was not an overall accepted cupcake in terms of taste. A majority of the panelists believed that the amaranth flour cupcake was bitter and nutty and did not find it to have a pleasant flavor. However, a couple of the panelists did enjoy and preferred it. Many of the panelists enjoyed the sample made with all-purpose flour and found it to have a sweet and pleasant flavor, and one panelist described it as the perfect cupcake. Overall, amaranth flour was determined to not be a suitable substitute for all-purpose flour in preparing red velvet cupcakes.

Further research could be done by including panelists that were celiac patients to determine their acceptability of the amaranth flour cupcakes. Another factor to include with further research would be to substitute different gluten-free flours and test their acceptability. Other flours may not have the nutty aftertaste that amaranth possesses and therefore make a more palatable dessert.

Budget

Ingredients	Purchase Unit	Cost per Unit	Amount Needed	Ingredient Cost*
Pillsbury All-Purpose Flour	2.27 kg	$ 2. 61	284 g	$ 0.33
Great Value All-Vegetable Shortening	1.36 kg	$ 3.83	192 g	$ 0.54
Great Value Pure Sugar	1.81 kg	$ 2.08	600 g	$ 0.69
Great Value Large Eggs	12 eggs	$ 1.48	4 eggs	$ 0.49
Hershey's Cocoa	453 g	$6.29	28 g	$ 0.39
McCormick Red Food Color	29 mL	$3.13	120 mL	$ 12.95
Morton's Salt	737 g	$ 0.84	16 g	$ 0.02
McCormick Pure Vanilla Extract	59 mL	$ 5.48	12 mL	$ 1.11
Prairie Farms Lowfat Buttermilk	0.95 L	$ 1.57	480 mL	$ 0.79
Arm & Hammer Pure Baking Soda	454 g	$ 1.50	20 g	$ 0.07
Great Value Distilled White Vinegar	473 mL	$ 0.82	32 mL	$ 0.06
Bob's Red Mill Organic Amaranth Flour **	623 g	$ 6.95	284 g	$ 3.16
Betty Crocker Rich & Creamy Cream Cheese Frosting	454 g	$ 1.68	908 g	$ 3.36
	Estimated Total Cost for All Ingredients:			$ 23.96

***Ingredient costs sourced from: walmart.com [Price Matched Murray, KY]__**
****Ingredient cost sourced from: thrivemarket.com**

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